Division of Marine Fisheries HubLine Eelgrass Restoration

Mid-project Progress Report

By

The Massachusetts Division of Marine Fisheries

Submitted to

The Department of Environmental Protection

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1.0 Executive Summary

This report serves as our 2012 annual report and mid-project update summarizing *MarineFisheries*' progress after three years of work to restore eelgrass to Salem Sound and Boston Harbor, funded as partial mitigation for Algonquin's HubLine pipeline impacts to eelgrass in Beverly Harbor. Our project began in 2010 when we received funding to restore 1.8 acres of eelgrass based on test planting performed in 2009 by Battelle. In 2010 we assigned the project manager and hired one full time project staff member, began project planning and worked on site selection and reconnaissance in the field. In 2011 staff was increased to two full time staff on the project in addition to the project manager. In 2011 we initiated full scale planting at the pipeline impact scar in Beverly and conducted additional test-plots and site selection data collection throughout Salem Sound and Boston Harbor. At the conclusion of the 2012 field season, we finished planting four sites in Salem Sound, for a total of 1.01 acres of eelgrass restored to Salem Sound. Salem Sound sites are Woodbury Point with 0.47 acres successfully planted, Middle Ground with 0.27 acres successfully planted, Juniper Cove which was planted but ultimately not successful and Fort Pickering with 0.27 acres successfully planted. Our focus for the 2013 field season will be full scale restoration at up to six sites in Boston Harbor, selected based on both Battelle and *MarineFisheries* test-plot results.

2.0 Background

The Massachusetts Division of Marine Fisheries (*MarineFisheries*) eelgrass restoration project is funded as part of the mitigation for impacts to eelgrass (*Zostera marina*) resulting from the Algonquin Gas Transmission, LLC, HubLine Pipeline Project (HubLine). HubLine involved the installation of a 30-inch diameter Liquid Natural Gas pipe, impacting approximately 1.8 acres of eelgrass in Salem Sound in 2003. The DEP 401 Water Quality Certificate (WQC) required post-construction monitoring to assess recovery of eelgrass within the impact scar. In 2008, an interagency working group agreed that the eelgrass impacted off of Woodbury Point had not recovered and therefore required mitigation. In November 2009 DEP amended the 401 WQC #W015087 and waterways license No.5491, requiring Algonquin Gas Transmission, LLC, to mitigate 1.8 acres of eelgrass habitat (Appendix A). In February 2009, Algonquin's representatives, TRC Environmental and Battelle, presented an Eelgrass Restoration Site Selection Analysis to the interagency working group (Battelle and TRC 2009a). The following autumn, Battelle reported on the results of their test plots (Battelle 2009b), planted to identify potentially suitable locations for full scale plantings at sites that rated well in their site selection model. *MarineFisheries* was selected to implement the full scale mitigation project, based on our track record and experience managing, planning and conducting eelgrass restorations. The resulting eelgrass restoration is referred to as "Hub3", to distinguish it from other Hubline funded restoration projects. *MarineFisheries* accepted the funds subject to the terms of the amended WQC and agreed to provide annual reports on the progress of the project and expenditure of the funds (Appendix B). *MarineFisheries* addressed the

annual reporting requirement with project updates on our blog (www.Seagrasssoundings.blogspot.com) for the 2011 field season (Appendix C). This report is the 2012 annual report and also a summary of all three years of the project (2010, 2011 and 2012), including detailed site descriptions, methods, site selection, test planting and results and discussion.

3.0 Methods

3.1 Permitting

MarineFisheries project staff obtained all required local, state and federal permits and authorizations, including Orders of Conditions (OOC) from the municipalities of Beverly, Salem, Boston and Nahant, and Army Corps of Engineers Category II permits that include approvals from Natural Heritage and the Board of Underwater Archeologists (Table 1). Approvals were for several $9m^2$ test plots as well as full scale planting of two acres total, distributed between sites that rated well in the Battelle and *MarineFisheries* site selection processes.

3.2 Site Selection

Site selection is arguably the most important step in eelgrass restoration. Sites that are not well chosen may lack the conditions needed for growth and expansion resulting in a high probability of transplant failure.

In 2009 three sites (Woodbury Point, in Salem Sound; Governors Island Flats and Deer Island Flats, in Boston Harbor), were identified as potential transplant sites, based on a preliminary transplant suitability model (PTSI) (Battelle and TRC 2009a) and the success of test-plots located at sites that rated well in the PTSI (Battelle and TRC 2009b) (Table 2). The model summarized existing information such as historical eelgrass presence, nearshore stressors, wave energy, sediment type and some field data in a GIS-based assessment. Battelle collected supplemental field data on one field visit in October 2008. Field data included substrate composition, observed depth limits of eelgrass growth, coastal morphology and Photosynthetically Active Radiation (PAR) readings. Battelle calculated an approximate range of percentage of light reaching the canopy (percentage of surface irradiance or %SI) using Kd (extinction coefficient) derived from Secchi Disk data and depth collected by Massachusetts Water Resources Authority (MWRA), and PAR readings from the October field day (Battelle and TRC 2009a). These data were analyzed with the DEP eelgrass map layer to identify light at depth in areas where eelgrass was present. The above characteristics and stressors were overlaid to obtain transplant site suitability ratings.

Site characteristics

In 2010 and 2011 *MarineFisheries* re-assessed Battelle's site selection model and re-visited the test-plot locations to gather more information on characteristics that are indicative of a good transplant site. In our assessment it became evident that more information was needed for us to be confident in planting at the locations selected by Battelle. Also, in addition to the three selected sites, there were many other areas that rated well in the 2009 PTSI throughout Boston Harbor, Salem Harbor and Marblehead, but were never test-plotted by Battelle. We surveyed these potential areas with drop camera and divers. Many areas were eliminated from consideration due to factors including depth, sediment type,

proximity to conflicting uses including dense mooring fields and wave energy. At promising sites we collected additional abiotic data, including surface sediment observations and light availability using HOBO continuous data loggers and LI-COR LI-192 Underwater Quantum 2π PAR sensors (Table 3), for several periods throughout the 2011 and 2012 field seasons. HOBO light data is presented as the average percentage of light at the canopy (% SI) in Lumens/ft^2 over two week deployments between 10:00 and 14:00. The LI-COR measures PAR quantified as µmol photons m^{-1} $second^{-1}$ which is a measure of the photosynthetic photon flux density (PPFD). PAR was derived from the average of single casts done while in the field on several days throughout the field season. Using LI-COR surface and submarine light sensors, both the absolute PAR as well as the percentage of PAR reaching the seafloor (% SI) can be measured. PAR is also used to calculate the light extinction coefficient, Kd (Carruthers et al. 2001).

Test plots

Based on our re-assessment of the Battelle model with the addition of our site specific field data collected in 2010 (Table 3) we selected three new sites in Salem Sound and three new sites in Boston Harbor to test plot in 2011. New test plots were planted at Fort Pickering, Juniper Cove and Middle Ground in Salem Sound (Figure 1) and Long Island East, Peddocks Island East and Lovell Island in Boston Harbor (Figure 2).

MarineFisheries test plots were 3mx3m plots at a density of 50 shoots /m^2 alternating planted and unplanted squares.

Reconnaissance and Site layout

Once a site was deemed suitable for transplants based on the Battelle site selection model, test plots and *MarineFisheries*'s drop camera work, we made further reconnaissance dives to delineate the most suitable planting area within the site. Reconnaissance began by setting two 50 meter transect tapes laid parallel and 35 meters apart. The dive team swam perpendicular between the tapes noting any characteristics in order to create a detailed map of the site. Final plot sizes and locations were determined based on the most suitable substrate, avoiding rocky areas and algae, for example. The selected site was marked with stakes and screw anchors with subsurface buoys.

3.3 Transplanting

Field schedule

The eelgrass restoration field season runs from late April through early November with the bulk of the planting taking place in May/June and September/October. We avoid the peak summer months for several reasons. July/August is the most stressful time of year for eelgrass due to the increase in water temperature and decline in water quality resulting in algae epiphyte growth. Furthermore, it is the reproductive season and morphological changes to shoots make them less suitable for transplanting, and the plants are generally too large to easily manipulate. Instead we focus on monitoring and locating additional transplant sites in the summer months. Our field team generally consisted of two divers and a top person for most field days.

Planting design

All planting sites were planted in checkered plots of alternating planted and unplanted 1 m^2 squares (Figure 3). The checkered pattern allows for a larger planted area while using fewer shoots and incorporates space for growth and expansion (Leschen et al. 2010).

Full-scale planting began in May of 2011 at Woodbury Point. In 2011 our site layout consisted of four, 18 x 30m planting plots, for a total ½ acre including the expected expansion area, i.e. the expected area that grass will grow into after three years. The 72 squares per plot were planted at a density of 24 shoots/m^2 for a total of 13,824 shoots planted in the ½ acre site (Figure 3).

In 2012 we redesigned our planting plan to improve efficiency and success based on our experience in the field (Table 3, Table 4). We changed our design from a relatively continuous checkered planting area to planting with several smaller checkered plots to reduce effort, time and risk for each site. Each site was approximately ¼ - ⅓ acre instead of ½ acre, in order to focus on planting more potentially suitable areas and tailoring the plots to the site conditions. Each site was planted with six smaller checkered plots, spaced across the site with the ultimate goal of expansion of the plots to encompass 1,100 m^2 (0.27 acres) or 1,375m^2 (0.34 acres) depending on site conditions (Figure 4). The 13 squares per plot were planted at a density of 50 shoots/m^2 for a total of 650 shoots per plot and 3,900 shoots per site.

Harvesting methods

All harvesting is done in accordance with DMF's eelgrass restoration guidelines (Evans and Leschen 2009) and with minimal impact to the donor bed. Divers harvest individual shoots along a 100m transect approximately 1-2 meters on either side of the transect tape, moving along the tape to disperse the collection. In order to ensure that harvesting impacts are minimized, only a few shoots (approximately 5%) are harvested from each m^2 area. Assuming a density of 300 shoots/m^2, which is typical at this site, no more than 15 shoots are harvested before swimming on to the next spot. GPS coordinates are recorded at each end of the transect to prevent repeat harvesting of the same area.

If shoots are not planted on the same day, they are stored in a wire mesh cage underwater until the following day for transplanting. Plants are transplanted within 48 hours after harvesting.

Harvesting occurred at donor beds near Pride's Beach in Beverly for Salem Sound planting sites and in Nahant Bay for Boston Harbor sites. In 2011 *MarineFisheries* divers also harvested plants from the Logan Airport runway safety area (RSA) improvement project footprint because they were expected to be impacted by construction. We used the Logan plants in our test plots in Boston Harbor and at the impact site at Woodbury Point. By the end of June, when construction began at the Logan site, divers shifted to harvesting plants at the Pride's Beach donor bed to finish planting at Woodbury Point (Figure 1).

Planting methods

We used three different planting methods: the horizontal rhizome (HR) method, the burlap disk (BD) method, and the rock method, in accordance with DMF HUB3 Standard Operating Procedures. The HR method entails planting two shoots together in opposite directions, with bamboo skewers anchoring the rhizomes to the sediment (Davis and Short 1997). This was the primary method used for test plots and

full scale planting in 2010 and 2011. The BD planting method, developed by Chris Pickerell at Cornell Cooperative Extension, was used by *MarineFisheries* to plant test plots in the fall of 2011 at the Fort Pickering site and was the primary method used for full scale plantings throughout Salem Sound in 2012. The BD method involves weaving 10 shoots into circular cuts of burlap that are then buried in an approximately 2-3 cm deep hole backfilled with sediment over the burlap and rhizomes (C. Pickerell, Cornell, pers. com. 2011). The third method, dubbed the 'rock method' was also developed by Chris Pickerell at Cornell Cooperative Extension. The rock method uses cobbles to anchor 4 to 8 shoots to the sediment by placing the cobble on top of buried rhizomes (C. Pickerell, Cornell, pers. com. 2011). At New York sites Chris's team has had success with the rock method where sediments are sandy with grape fruit sized rocks at the surface (http://www.seagrassli.org/). In some cases, where sandy sites lacked sufficient numbers of rocks, they brought their own rocks to use as anchors. *MarineFisheries* used the rock method in one test plot at Lovell Island, an outer island site in Boston Harbor.

Method comparison study

The effectiveness of the HR method is better known than the new BD method. Therefore, to test the relative success of the BD method compared to the HR method we collaborated with Chris Pickerell in a method comparison study, as part of his larger method test which also includes sites in Long Island Sound and Rhode Island. Our method comparison study at Fort Pickering included a total of four test plots; one plot using the HR method and one plot planted with the BD method at each of two depths, shallow (6ft MLW) and deep (12ft MLW) (Figure 5). We primarily used the BD method for planting in 2012 due to the method's success at test plots in 2011 and the coarser, sandy sediment at all of our sites in Salem Sound.

Volunteer days

MarineFisheries hosted two volunteer field days where volunteers worked on the beach to weave eelgrass shoots into the burlap disks used for planting with the BD method. Volunteer groups were from Salem Sound CoastWatch and the New England Aquarium. A summary of the field events with pictures and links to other useful sources can be found on our blog, www.SeagrassSoundings.blogspot.com. We plan to host two more volunteer days in 2013 for the Boston Harbor plantings.

3.4 Monitoring

Transplant sites

In 2011 and 2012, monitoring at all sites was done one week post-planting and again at one month, six months, and one year. In addition to these scheduled events, some sites were monitored before and after coastal storms to assess the impact. In 2011, Woodbury Point was monitored after Hurricane Irene which occurred 2-3 months after planting. In 2012, Middle Ground and Woodbury Point were monitored before and one week after Hurricane Sandy, about four months after initial planting.

In 2011, divers swam over each plot and noted presence/absence of the originally planted squares (i.e. $1m^2$ quadrats). In addition, eight of the planted squares were randomly sampled from each plot to quantify shoot density and percent survival at the one month and one year monitoring intervals at all full scale planted sites. At test-plots, shoot density was counted in all planted squares.

In 2012, we modified the monitoring procedure for our full scale planted sites to account for the new planting method and site layout. At each site, divers visited all 6 planted plots and randomly selected four quadrats from each to measure shoot density (Figure 4). In addition, the bed extent of each of the six plots was measured along three axes (length, width, and diagonal) of the plot to quantify expansion at the one month and one year monitoring intervals. This monitoring method will continue for three years at all planted sites to determine the overall expansion of the plantings through lateral growth and seeding, and finally to calculate the area successfully restored.

Reference beds

We have six reference beds, three in Salem Sound and three in Boston Harbor, which we plan to monitor for comparison with our transplanted sites in order to calculate success (Short et al. 2000). Reference beds were located using a drop camera and targeting mapped eelgrass beds at similar depth contours, bottom type, and water conditions as the restoration sites. An effort was made to locate the bed edge at the Pride's Beach and West Beach reference sites for a closer comparison to the Woodbury point restoration site, which is also at the edge of the bed.

In 2011 and 2012, due to time and weather constraints, we monitored only one of our three reference beds; our SeagrassNet monitoring station at West Beach in Beverly (Figure 1). We monitored 12 quadrats at each of three transects, recorded shoot density, percent cover and canopy height and measured the extent of the bed. Monitoring of all three reference beds is scheduled for the 2013 field season.

Donor beds

Our donor bed for the Salem Sound transplant sites is near Pride's Beach in Beverly and for the Boston Harbor transplant sites the donor bed is off Nahant (Figure 1, Figure 2). Past donor bed monitoring has shown that harvesting by hand and individually picking shoots in a dispersed manner has no quantifiable effects to donor beds. Because we are using this low impact harvesting technique, we will not be monitoring the donor beds.

4.0 Site descriptions, Results & Discussion

4.1 Beverly (Woodbury Point)

Site selection

The Beverly site (known as Woodbury Point) (Figure 1) is the pipeline impact scar. In *MarineFisheries* 2010 reconnaissance we described the scar as a large unvegetated area of fine sand with patches of course gravel, assumed to be the plowed backfill left after pipeline construction. The unvegetated scar was bordered on the shallow end by a natural patchy eelgrass meadow, with some small patches of grass interspersed within the scar.

Woodbury Point rated well in the Battelle site selection model (Battelle and TRC 2009a) meeting many key criteria for a good transplant site (Table 3). Woodbury Point had the highest water clarity of all test plot locations and the lowest percent fine grain sediments (Battelle and TRC 2009a). In 2009 Battelle planted test-plots at the shallow and deep edge of the impact scar. The Woodbury Point test plots had the highest survival of all 2009 Battelle test-plots (64%) and survival was within the range of that

reported for other successful transplant sites in New England (Estrella 2006, Kopp and Short 2001, Davis and Short 1997). In addition, the scar was bordered by patchy eelgrass and reportedly supported a continuous meadow before the pipeline impact, so we expected conditions would enable a jump start to recolonization through transplanting.

Percent of light at depth at Woodbury Point was estimated by Battelle in 2009 to be 10-20% surface irradiance (SI). Calculations based on our PAR measurements yield an average of 15% SI (Kd of 0.41), which is consistent with EPA measurements reported for this area (M. Liebman, EPA, pers. com. 2013). The percent SI measurements are on the lower end of the range often reported for eelgrass survival and growth (Olesen and Sand-Jensen 1993, Lee et al. 2007, Duarte 1991). For comparison, our reference bed light levels were 23% SI at similar depths. Since the light levels at Woodbury point are 5-10% less than at the reference bed, we consider light marginal at Woodbury Point, particularly at the deeper plots (Table 3).

In addition to LI-COR we also used HOBO pendant monitors to measure light availability. LI-COR PAR sensors are the best way to measure the actual amount of light usable by seagrasses (i.e. PAR), but the less expensive HOBO loggers can be used to assess relative light and provide a longer term light measurement through continuous logging for two weeks at a time. In temperate waters, percent SI measured with HOBO monitors is lower than percent SI measured with a LI-COR PAR sensor because the two instruments measure different portions of the light spectrum, which are absorbed differently through the water column (Carruthers et al. 2001). HOBOs deployed in June 2011 at approximately 12-15 ft MLW depth, recorded an average of 3.4% SI at Woodbury Point. The reference site Hobo percent light was measured in April and October and the average was 4.2% SI at 12ft MLW. Because the HOBO data were collected at different times of year we cannot compare them directly. However, both reference site and transplant site HOBO light data are within the range recorded at other northern New England seagrass sites (Alyssa Novak, UNH, pers. com. 2012).

Despite the lower light levels we decided to plant a full scale restoration at Woodbury Point for several reasons; 1) the 2009 Battelle test plots at Woodbury Point had the highest success of all plots planted, 2) the site was recently vegetated and is flanked by eelgrass meadows to the east and west at similar depths, indicating that the site is within the depth range of eelgrass growth for the area, 3) the site is the impact scar, and an on-site, in-kind restoration would directly replace the resource where it was lost which is preferable from a habitat perspective.

2011 Planting

One month after transplanting at Woodbury Point monitoring results showed 97% of the planted squares were still present; with an average of 59% shoot survival (15 shoots/ m^2 compared to the 24 shoots originally planted) for each square. This initial loss of plants is typical of eelgrass restoration. Our survival measurement is close to the survival recorded by Battelle (64%) for test plots planted in 2009 at the same site, and it is higher than the survival at all test plots planted in Boston Harbor in 2009. Transplant survival at Woodbury Point is also consistent with that found in other restoration sites in New England. Kopp and Short (2001) reported survival of 55% - 73% after one month at sites that they

deemed successful in New Bedford and Fairhaven; *MarineFisheries* (Estrella 2006) reported 45% to 85% survival after 6-8 weeks at test plot sites in Boston Harbor.

In mid-August the plants were surviving with evidence of new growth. On August 28, 2011 Hurricane Irene hit New England. Post-storm monitoring found large sand waves across the site with areas of burial and other areas of erosion. We estimated a loss of approximately 75 - 80% of the planted eelgrass. By the end of August, approximately three months after planting, monitoring results showed 25% of the planted squares were still present; with an average of 20% mean shoot survival (4.8 shoots/m^2) in the remaining vegetated squares, resulting in a 4% mean shoot survival overall for the site (Table 4, Figure 6). There was no apparent difference in storm resistance between plants from the Logan bed and plants taken from Pride's Beach or plants at the shallower vs. deeper plots. By comparison, the reference bed at the Misery Island SeagrassNet site did not show a significant decline after Hurricane Irene when monitored in October 2011. However, by July 2012 shoot density had declined by greater than 50% (240 shoots/m^2 to 100 shoots/m^2 at the mid-depth transect) compared to the previous year. This may indicate a delayed response to the storm at the established reference site.

We conclude that the storm was the major cause of transplant failure at Woodbury Point in 2011. However, transplants were declining before the storm hit. Eelgrass persists naturally adjacent to and at the same depth as our restoration site, so we initially concluded that the site was not too deep for planting. However, it's possible that the loss of eelgrass after trenching of the HubLine pipeline changed the dynamics of the area, making it less stable and more vulnerable to wave and current action than it had been when an established eelgrass root and rhizome system was present. The geochemical composition of the sediments may have also changed after eelgrass below ground structures and detritus layers were lost. If this is the case, the changing physical dynamics of the site combined with marginal light conditions may limit eelgrass restoration success, despite natural grass growing nearby. These factors may explain why eelgrass did not revegetate the scar naturally.

2012 planting

The planting site at Woodbury Point proved to be a higher energy site, more vulnerable to storm impacts and deep edge stresses than initially thought. In 2012 we reassessed our planting design and decided smaller, denser plots and in some cases shallower sites had a better chance for survival and expansion. Smaller, high density plots have been shown to offer more protection in higher energy areas than larger more sparsely planted plots (Gaeckle 2006). Lateral growth of eelgrass patches has also been found to increase when the patches are smaller (Olesen and Sand-Jensen 1993).

Initial monitoring in the spring of 2012 showed a post-hurricane Irene rebound, particularly at the B-2 plot which was on the shallow edge of the depth contour (Figure 3). Overall we noted that the shallow portions of the site, 50% of the original area planted, rebounded with evidence of new shoot growth and approximately 6 shoots/m^2 density.

We abandoned the deep plots that did not recover from the hurricane and augmented the portion of the site that still had eelgrass. In June and September, with the help of volunteers from the New England Aquarium weaving plants onto BDs, we planted 6 plots with 13 planted squares each spaced in

a checkered pattern, totaling 150m^2 (planted) spread across a 1,375m^2 (0.34 acres) expansion area (Figure 4). This new planting site extends along the shallow depth contour from the most successful of the original plots, B-2. By September, eelgrass planted at Woodbury Point in the spring and summer of 2012 increased in shoot density with a survival above 100% (i.e. shoot density greater than that originally planted) at 5 out of 6 plots. The three northern plots were the most successful with survival of 124%, 104% and 113% respectively. In October with early warning of Hurricane Sandy, we were able to survey the plots before the storm and again a few days after the storm. Monitoring three days after Hurricane Sandy showed that density at all plots declined an average of 27% to between 59-102% survival compared to what was originally planted (Figure 7). Our next scheduled monitoring is in summer 2013.

4.2 Fort Pickering

Site Selection

The Fort Pickering site is located on the eastern side of Winter Island adjacent to Waikiki Beach and in a protected cove (Figure 1). The sediment is composed of fine sand and mud and the depth range is 6 – 12 ft MLW. Early reconnaissance found some isolated patches of eelgrass. Fort Pickering rated well in Battelle's PTSI model and was among the sites that *MarineFisheries* selected for test plotting in 2011.

Our 2011 site characteristics assessment and test plot results were promising (Table 3). After one month, as expected all test-plot squares experienced a small decline to 44-87% survival compared to the originally planted density. The remaining shoots were rooted with evidence of new growth. After 6-8 months, the plants showed new growth and had an average of 118% survival. Percent light at Fort Pickering test plot sites was within the range deemed acceptable for transplanting (Table 3, Lee et al. 2007, Duarte 1991). Due to the overall success we planned a larger restoration effort for the 2012 season.

Method comparison study

At Fort Pickering there was little difference between methods (HR and BD) one week after planting at the shallow location (96% BD and 95% HR) but there was a greater difference at the deep site (99% and 83%). At one month the difference between methods was evident at both deep and shallow sites. Percent survival of planted shoots at shallow and deep BD sites was 87% and 81% respectively, compared with 56% at the shallow and 44% at the deep sites using the HR method. After two months the shallow BD plot had 82% survival and the shallow HR had 44% survival of planted shoots. The deeper test plots showed an even more pronounced difference with a survival rate of 76% BD vs. 31% HR. Six months post-transplanting, all plots had rebounded, exceeding 100% of the original density and the difference between methods was less evident than before. Overall the BD method outperformed the HR method at both the shallow and deep sites (35% higher density at the shallow site and 15% higher density at the deep site). For both methods the shallow plots did better than the deep plots (28% and 9% higher density compared to the deep site for the BD and HR methods respectively).

The BDs are about twice as fast to plant compared to the HR method, but constructing the BDs requires more time on shore. Utilizing volunteers to tie grass into the BDs is a good way to reduce the time required and the outreach adds to the project benefits.

Our anecdotal experience indicates that the BD method works better in sandy sediment and higher energy sites and is not as effective in fine grain sediments. The BD method involves digging in the sediments which can produce a lot of resuspension causing visibility to temporarily drop to zero in some cases. Therefore, it is very challenging to use this method in muddy sediments. Conversely the HR method is preferred when sites have fine grain and muddy sediments because there is less sediment disturbance in the planting process. Also, in high energy sites we found that erosion exposed the skewered planting unit more easily then the buried burlap disks. Occasionally when planting in lower visibility the BD was not buried fully and in those few cases the burlap was found uprooted and could be a target for bioturbating crabs. This potential problem was greatly reduced when planting in courser sediments and better visibility and when divers went back over recently planted plots and checked that they were buried.

Our test plots at Fort Pickering were all considered successful. Based on the successful results of the site selection and test plots we planned to continue planting at the Ft. Pickering location in 2012. Given the higher success of the BD method in the silty sand of Fort Pickering we decided to use the BD method at our sandy and silty sand sites in 2012. In 2013 we plan to plant sites in Boston Harbor with a mix of both methods depending on each site's characteristics.

2012 Planting

Fort Pickering had a 5.1% SI calculated using the HOBO light level and is close to that measured at our deep reference bed (Table 3). Based on the results of the 2011 test plots we focused our restoration efforts on the shallower portion of the site where the shallow BD method had the most success. With the help of volunteers from Salem Sound CoastWatch, *MarineFisheries* planted at Fort Pickering near the shallow test plot site in June of 2012. Six plots totaling 150m^2 were spaced out in a checkered pattern covering an expansion area of 1,100m^2 (0.27acres).

At the two week monitoring event all plots were maintaining density at an average of 93% survival. By three months after planting densities had dropped to an average of 68% survival for the south transect plots. The North transect plots were damaged by a string of lobster traps and an algae mat which smothered the two of the three plots, N10-15 and N30-35. At our last monitoring event in October 2012 the lobster pots had been removed and plants were rebounding in the N10-15 plot (Figure 8). The overall site had an average survival of 48% after 6 months (Table 4), and the south transect alone had increased to 73% survival.

4.3 Middle Ground

Site selection

Middle Ground, also known as Aqua Vite, is the shoal northeast of the mouth of Salem Harbor with depths of 6- 12 feet at MLW (Figure 1). This area has anecdotally had abundant eelgrass in past decades. It is currently sand and gravel with larger rocks, algae and tunicates in some areas. There are also a few small, scattered eelgrass patches. Light measured using the LI-COR PAR sensor was 21% SI with a Kd of 0.42, showing adequate light for eelgrass growth contributing to the suitability of the site for transplanting (Table 3, Lee et al. 2007, Duarte 1991).

2011 Test plots showed good results after one month with 77% survival. After 6-8 months, the plants showed new growth and had maintained a consistent density and 78% survival.

2012 planting

Middle Ground is our most successful restoration site to date (Table 4). Plots were planted throughout July 2012 and all plots increased in density to above 100% survival by September (ranging from 132% to 165%). Growth and expansion continued into the fall when plots almost doubled, reaching 187% of the originally planted shoot density. But, a few weeks after Hurricane Sandy all plots had declined back to September levels with a mean of 126% survival (Figure 9). We are hopeful that the plots will continue to grow and expand by this summer's scheduled monitoring.

4.4 Juniper Cove

Site selection

Juniper Cove is a small cove on the northeast side of Winter Island in Salem (Figure 1). The cove is well protected from all directions except the southeast. Sediment is silty sand and there are some small patches of eelgrass existing in the cove. Much of the cove drains out at low tide and there is a wide mudflat. The area selected for test planting is approximately 3 feet at MLW. Several moorings are located in the deeper portion of the cove adjacent to the potential eelgrass planting site.

Initial one month test-plot results at Juniper Cove were promising with 71% survival of originally planted shoot density and evidence of new growth. The trend of new growth continued with many new lateral shoots produced through the early spring. At 6 months, April 2012, Juniper Cove had 130% survival (i.e. 68 shoots/m^2, compared to the 50 originally planted). Juniper Cove had the highest light availability (43% SI with a Kd of 0.47) (Table 3), likely because it is the shallowest site monitored. Juniper Cove was selected for full scale planting based on the suitable site conditions most notably the high light, sandy sediments, low fetch and successful results of the 2011 test plots.

2012 planting

In May through July 2012 we planted one BD plot and two HR plots in a 750$m^{2,}$ (0.19 acre) area along a shallow contour in Juniper Cove.

After one month the first planted plot (S 0-5) was estimated to be over 100% survival. At the end of July, we returned to the site to monitor the success of the second plot and to plant our third plot. However, divers documented mats of green and red algae smothering the deeper portions of site. We continued to plant the shallow plot, which was not blanketed in algae. Based on anecdotal information from the harbormaster, we learned that debris and algae are blown into the cove by persistent winds through late spring and summer when they get pushed back out. Since we originally planted the test plot in the fall of 2011 and assessed the success the following spring 2012 we missed the summer algae mat for our test plot assessment. By August the deep plot was smothered and in poor condition and the augmented shallow plots showed less than 5% survival (Table 4, Figure 10). These results highlight the importance of seasonal differences in planting success and the need to assess test plots for at least one year. Due to the poor success we abandoned the Juniper Cove site.

4.5 Salem Sound, West Beach Reference Bed

The Salem Sound reference bed is located off of West Beach in Beverly and is characterized by a large natural eelgrass meadow that spans between West Beach and Misery Island (Figure 1). This is one of the largest natural beds in the region. Depths at the reference meadow coincide with the depths at the restoration sites. *MarineFisheries* has been collecting data at the West Beach site for six years as part of the SeagrassNet worldwide monitoring protocol. Data collected in July from 2010 to 2012 was used for comparison to our transplanted sites during the same time period.

Figure 11 shows the percentage survival of planted shoots at each transplant site compared to the percentage change in shoot density at the reference bed for the same time period. While the reference bed maintained a generally consistent shoot density over the 2012 growing season, each transplant site followed a different trajectory. Percent survival of shoots at Juniper Cove declined sharply in the late summer, survival at Fort Pickering declined throughout the season but shoot density rebounded slightly in the fall, Woodbury Point shoot survival increased throughout the season and then declined in the late fall. The reference bed was not monitored immediately after Hurricane Irene, so no comparison could be made regarding direct storm impact between our restoration sites and the reference bed. Long term monitoring is integral to our restoration efforts to show comparisons between the natural and restored sites.

4.6 Governors Island Flats and Deer Island Flats, Boston Harbor

Site selection

Governors Island Flats and Deer Island Flats are located in the Outer Harbor adjacent to the President Roads channel (Figure 2). Sediment at both sites is fine sand and mud. The location near the channel results in higher flushing and courser sediments which are better suited for eelgrass as compared to other sites in Boston Harbor which consist largely of organic mud (Table 3). 2009 Battelle test plots at Governors Island Flats and Deer Island Flats had survival of 34% and 36.5% respectively after four months. Percent survival was higher at these sites than at all other Boston harbor test-plot sites planted in 2009 by Battelle (Battelle and TRC 2009b, Table 2). However, survival here was still lower than what has been reported in other successful transplant studies (Estrella 2006, Kopp and Short 2001, Davis and Short 1997). At both sites, shoot survival at the shallow Battelle test-plots (approx. 5-6 ft MLW) outperformed the deep test-plots (approx. 7-8ft MLW) and therefore Battelle recommended restoration at the shallow portion of both sites.

In 2010 *MarineFisheries* collected additional site selection data at Boston Harbor sites. Light and sediment measured at the Deer Island and Governors Island sites was lower than all other sites sampled (Long Island East and all Salem Sound sites) (Table 3). The relatively low measured percent light combined with the fine sediment, likely with high organic matter content, may predict a stressful environment for eelgrass transplants. However, these sites are the best potential planting sites that we have found in Boston Harbor.

Planting was delayed at sites near Logan Airport due to construction at Runway 33L. The construction project included the use of barges that navigate over Governors Island flats and moor near the planned planting site. In-water work at the runway was completed in November 2012. Therefore we plan to

resume planting test plots in shallow areas at Governors Island and Deer Island sites in the spring of 2013.

4.7 Long Island East, Boston Harbor

Site Selection

The East side of Long Island is protected by surrounding islands to the north, north east, southwest and south east. However, currents and waves from boat traffic move quickly around Bass Point.

The two test plots on the east side of Long Island (LIE) were planted in September 2011 in an area of mud and fine sand and 6-12 ft MLW depth. After one month the southernmost plot had been replaced by a mat of *Crepidula spp*. (commonly called slipper shells) and algae. The northern plot was present (73% survival from original planted density). After 6 months, April 2012, the northern plot declined to 68% survival and after one year, October 2012, the plot was completely gone. The entire area had a mat of algae and *Crepidula spp*. snails that likely settled and smothered the remaining plants. Based on these results we will not plant additional plots at the same depth contour at LIE. We plan to re-visit the East side of Long Island in spring 2013 to investigate the possibility of planting a test-plot at a shallower and more protected location.

4.8 Lovell Island

Site Selection

The shallow waters around Lovell Island have a cobble pebble bottom that previously excluded the area from the list of viable transplant sites (Short et al. 2002, Estrella 2005, Battelle and TRC 2009a). But because sites with suitable water quality are limited in Boston Harbor, we looked more closely at the outer Harbor Islands for potential transplant locations. The rock method may be a solution to enable transplanting in these areas.

Initial results were promising at the cobbly Lovell Island. We tested the rock method in fall of 2011 in the shallow slope at the south east corner of Lovell Island. The test plot plants were still present one month after planting. However, no shoots remained after 6 months. We believe the substrate beneath the cobble was too gravelly and not sandy enough for shoots to take hold. Eelgrass obtains nutrients from the pore water in the sediments and a gravel bottom does not retain the required nutrients for plants to survive. The method may be useful in areas where cobble overlays sandy or silty substrate. Unfortunately this combination has been difficult to find around the Boston Harbor Islands.

4.9 Thompson Island

Although it had ideal sandy conditions, Thompson Island north proved to have a high current and fetch and therefore is not suitable for transplanting. The Thompson Island HOBO was not recovered and was deemed lost after two attempts to locate it. We did not plant a test-plot at this location due to the high current and wave energy.

The bay east of Thomson Island was also investigated and ruled out due to muddy sediments and low visibility.

4.10 2012 Outer Islands

Due to the challenges of the Boston Harbor habitat for eelgrass planting and the recent record of low planting success by other projects (Aecom 2012), *MarineFisheries* continued reconnaissance of the Outer Harbor Islands at sites that were excluded in the past, after chart and aerial photo assessment grouped them as having rocky substrate or high wave energy. The objective of reassessing the area was to find smaller, protected, pocket sites that may have been overlooked, or sites that may be successfully planted using a variety of methods including the rock method. The two day reconnaissance involved one day of drop camera work to survey the broader area and one day of SCUBA diver groundtruthing of sites that appeared to be the most suitable. We believe the following locations are suitable for test plots to be planted in 2013:

Green Island

The northwest shore of Green Island contains a small, shallow harbor with patches of sand and large boulders throughout. We estimate that there is approximately a half acre of potential planting area.

Great Brewster Island

The southwest shore of this island contains rocky and sandy areas. Divers noted cobble and gravel over sand with abundant *Crepidula sp.* snails and green crabs, some boulders and attached algae in one area of the site while other locations were more promising with continuous sandy areas. There is potential for this to be a small restoration site but further reconnaissance is needed to determine the actual area suitable for planting and assess bioturbation concerns.

Gallops Island

The southern shore of this island has sandy substrate with shell hash and some gravel and cobble. Divers noted that it looks like a good area for a test plot and potentially full-scale planting due to the sediment composition throughout the site and the protected location near a rock spit inside day marker #7 of the channel. We estimate approximately a half acre of potential planting area.

5.0 Project budget and expenditures to date

The Hub3 funds are divided into three main categories, 1. personnel, including salary and benefits, dive pay and travel costs, 2. equipment and supplies, including field gear such as tape measures, screw anchors and buoys, dive gear, boat and truck fuel and, 3. permitting expenses.

Personnel includes a project manager (Tay Evans) at 10 hours per week (25% time), an Aquatic Biologist (Wesley Dukes) at 40 hours per week (100% time), a Fisheries Technician (Jillian Carr) at 40 hours per week (100% time) and Contract Technician (Kate Ostrikis) at 19 hours per week (50% time).

Item	Fiscal Year				Total
	2010	2011	2012	2013	
Personnel	$66,799.27	$76,239.65	$148,158.96	$83,635.77	$374,833.65

Equipment and supplies	$2,463.48	$9,696.28	$10,141.05	$88.60	$22,389.41
Permitting		$683.40	$386.99		$1,070.39
Total	**$69,262.75**	**$86,619.33**	**$158,687.00**	**$83,724.37**	**$398,293.46**

6.0 Next Steps and 2013 field season plans

In 2013 we will focus on Boston Harbor. We plan to plant small plots at the above mentioned Outer Harbor Island locations and at shallow sites along Deer Island, Governors Island Flats and Long Island East. We will continue to monitor our transplant and reference sites in Salem Sound, Nahant and Boston Harbor.

7.0 References

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Tables

Table 1. Permitting agencies and permit filing and approval dates.

Site	Permit or Approval	Application Filed	Approval Date
Salem Sound	Beverly - NOI	9/9/2010	9/24/2010
	ACOE - PGP CAT II	9/10/2010	10/13/2010
	BUAR	9/10/2010	9/15/2010
	MHC/SHPO	9/10/2010	9/20/2010
	Salem - NOI	3/28/2012	4/27/2012
Boston Harbor	Boston - NOI	4/6/2011	5/2/2011
	ACOE - PGP CAT II	4/20/2012	8/15/2012
	BUAR	4/20/2012	4/26/2012
	MHC/SHPO	4/20/2012	
	Nahant - NOI	5/10/2012	5/29/2012

Table 2. Monitoring results for nine sites planted with test-plots in 2009. Three sites with the highest percent survival (shown in italics) were identified as potential sites for full scale planting. (Reproduced from November 2009, TRC and Battlelle Eelgrass restoration test planting evaluation).

	Shoot Density (m^2)	# Shoots	Survival (%/m^2)
Beverly (Woodbury Pt.)	25.61	461	64.0
Hull	1.33	24	3.3
Slate Island	0	0	0
Thompson Island S.	0.33	6	0.8
Old Harbor	0.16	3	0.4
Governor Island Flats	13.61	245	34.0
Quincy Bay	0	0	0
Deer Island Flats	14.61	263	36.5
Hough's Neck	0.11	2	0.3

Table 3. Site selection and physical characteristics data for potential sites investigated by *MarineFisheries* from 2010-2012. Light and sediment observations collected by Battelle‡ in 2009 and *MarineFisheries in 2010-2012. (HR=horizontal rhizome; BD=burlap disk)**

Site	Harbor	Depth (ft; MLW)	% Light at canopy (HOBO*)	% Light at canopy (Licor*)	Kd (Licor*)	% Light (estimate‡)	Kd (estimate‡)	Sediment Obs.	Battelle model	Test-plot	Full-scale planting
Peaches Point Marblehead	Salem Sound	6-12	-	-	-	-	-	fine sand/ mud	good / marginal	No, sediment too rocky	No
Salem Harbor near Palmer Cove	Salem Sound	<6	-	-	-	-	-	silty sand/ mud	excellent	No, poor visibility, poor water quality, muddy sediments	No
Fort Pickering	Salem Sound	6-12	5.17	-	-	35-50	-	fine sand/ mud	excellent/ good	2011: 2HR+2BD: deep and shallow. High survival	Yes - 2012
Juniper Cove	Salem Sound	<6	12.59	43%	0.47	35-50	-	Sand / shell	excellent	2011: 1HR plot. High survival	Yes - 2012
Woodbury Point	Salem Sound	12-15	3.4	15%	0.41	10-20	.685	Sand / fine sand	marginal	2009: Battelle. High survival	Yes - 2012
Middle Ground	Salem Sound	6-12	8.13	21%	0.42	20-35	-	Sand / gravel	poor	2011: 2HR deep and shallow. High survival	Yes - 2012
Dead Horse Beach	Salem Sound	<6	-	-	-	-	-	Sand/ gravel	excellent	No, poor visibility	No
West Beach (deep reference)	Salem Sound	12-16	4.2	23%	0.30	-	-	Fine sand	good/ marginal	N/A, reference bed	No, reference bed
West Beach (shallow reference)	Salem Sound	6-12	5.6	33%	0.30	-	-	Fine sand / clay	good/ marginal	N/A, reference bed	No, reference bed
Governors Island Flats	Boston Harbor	<6	2.66	-	-	10-20	0.576-0.690	Mud / fine sand	very good	2009: Battelle. Low survival	No
Deer Island	Boston Harbor	6-12	1.33	-	-	10-20	0.576-0.690	Mud / fine sand	marginal	2009: Battelle. Low survival	No
Lovell Island	Boston Harbor	<6	-	-	-	-	0.529-0.575	Rock/ cobble	poor; adjacent to excellent	2011: Rock method. Low survival	No
Long Island East	Boston Harbor	6-12	7.4	-	-	10-20	-	Mud / fine sand	good	2011: 2HR plots. Low survival	No
Green Island	Boston Harbor	<6	-	-	-	-	-	Patchy sand and boulders	poor	Planned for 2013	Planned for 2013
Great Brewster Island	Boston Harbor	6-9	-	-	-	-	-	gravel over sand	poor	Planned for 2013	Planned for 2013
Peddocks Island East	Boston Harbor	<6	-	-	-	20-35	0.529-0.575	Mud / fine sand	very good	2011: 1HR plot. Low survival	No
Thompson Island North	Boston Harbor	<6	-	-	-	-	-	Mud / fine sand	good	2005: TERFS as part of HUB1; Low survival	No
Gallops Island	Boston Harbor	4-12	-	-	-	-	-	sand/ shell hash	excellent	Planned for 2013	Planned for 2013
Calf Island	Boston Harbor	8-10	-	-	-	-	-	sand/ gravel	poor	No, very small suitable area	No
Little Calf Island	Boston Harbor	8-12	-	-	-	-	-	sand/ gravel	poor	No, very small suitable area	No

Table 4. Summary of full-scale restoration planting sites, methods and results.

Year Planted	Site	Layout	Method	% Survival after 6 mos.
2011	Woodbury Point	½ acre. Four ⅛ acre continuous checkered plots	Horizontal Rhizome 24 shoots/m^2	4% / 0.13 acre
2012	Woodbury Point	⅓ acre. Six 5m x 5m evenly spaced checkered plots in 25mx55m area	Burlap Disk 50 shoots/m^2	82%
2012	Middle Ground	¼ acre. Six 5m x 5m evenly spaced checkered plots in 20mx55m area	Burlap Disk 50 shoots/m^2	126%
2012	Fort Pickering	¼ acre. Six 5m x 5m evenly spaced checkered plots plots in 20mx55m area	Burlap Disk 50 shoots/m^2	48%
2012	Juniper Cove	⅛ acre. Three 5m x 5m evenly spaced checkered plots	Burlap Disk & Horizontal Rhizome 50 shoots/m^2	3%

Figures

Figure 1. Locations of Salem Sound transplant sites (green circle), harvest site (red circle), and reference beds (gray circle).

Figure 2. Boston Harbor Sites.

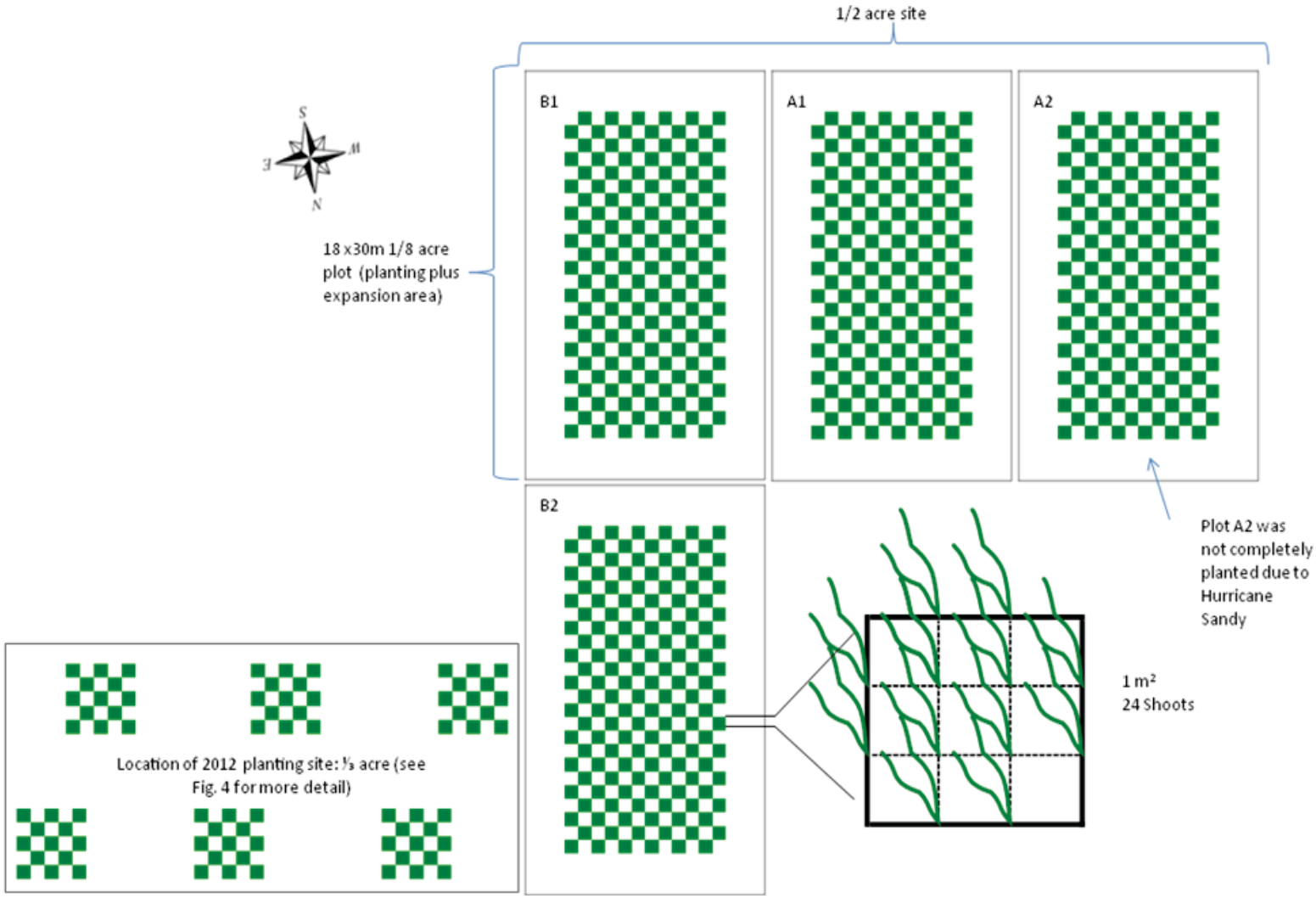


Figure 3. Layout of Woodbury Point site. In 2011 four large checkered plots were planted in alternating vegetated squares totaling approximately ½ acre including the expansion area. In 2012 an additional approximately ⅓ acre site was planted with six smaller plots.

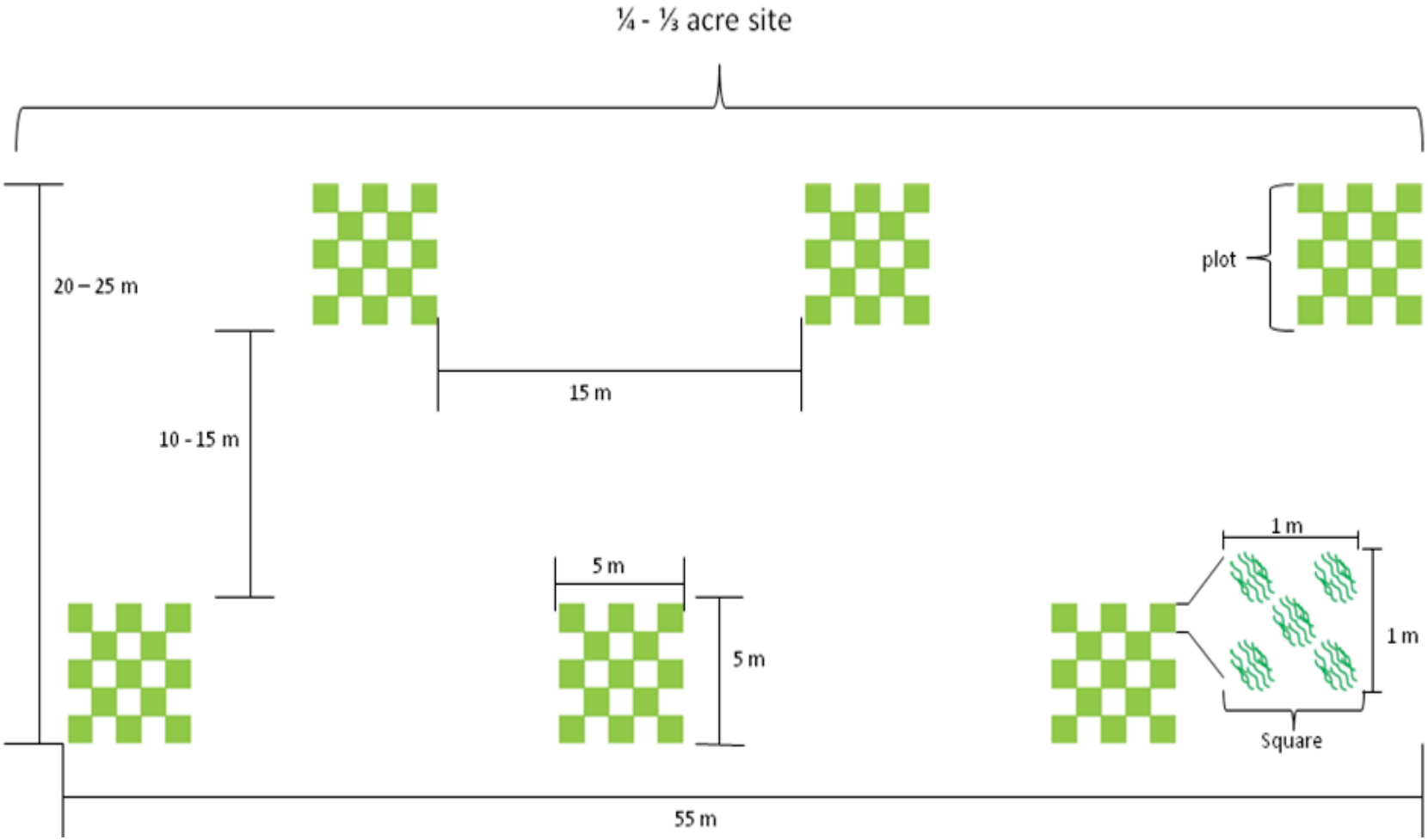


Figure 4. Layout for restoration sites planted in 2012 at four locations - Woodbury Point (⅓ acre), Middle Ground, Fort Pickering (¼ acre each) and Juniper Cove (¼ acre planned, planting aborted). Six 5m x 5m plots each in a checkered pattern of planted and unplanted squares. Three evenly spaced plots are planted along the North transect and three evenly spaced plots are planted along the South transect.

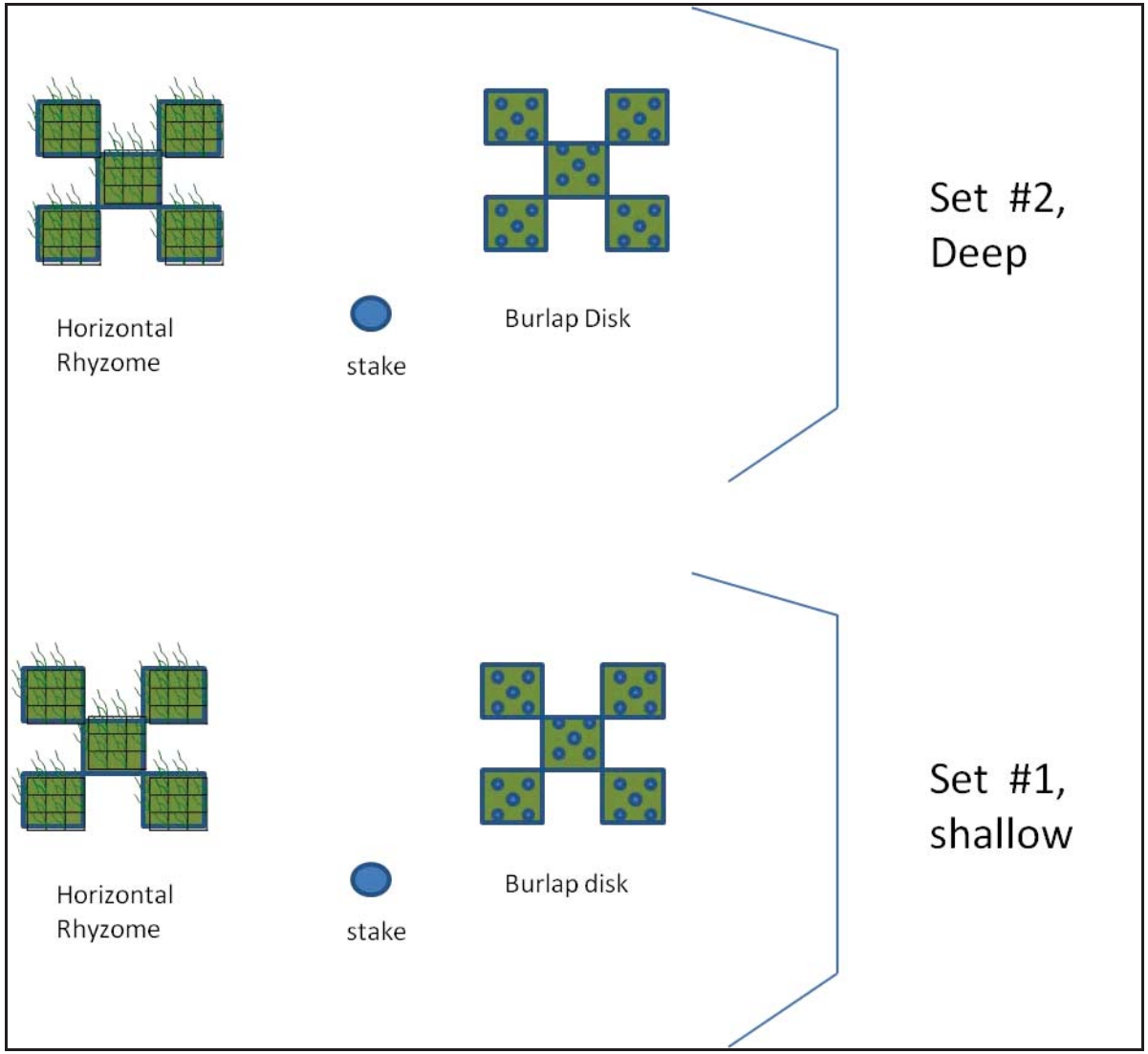


Figure 5. Test plot layout at Juniper Cove. Horizontal Rhizome and Burlap Disk method comparison site.

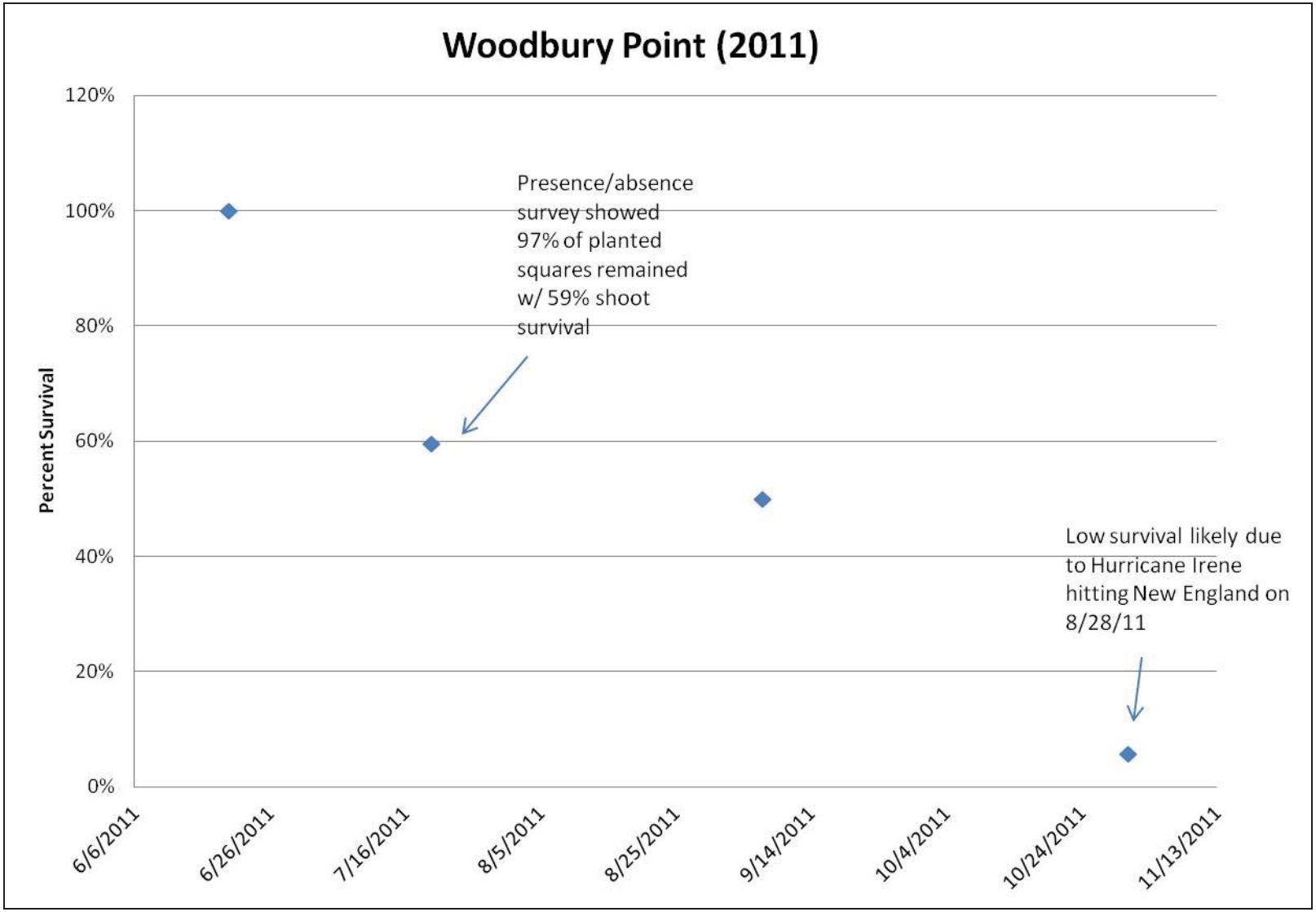


Figure 6. 2011 monitoring data for Woodbury Point site.

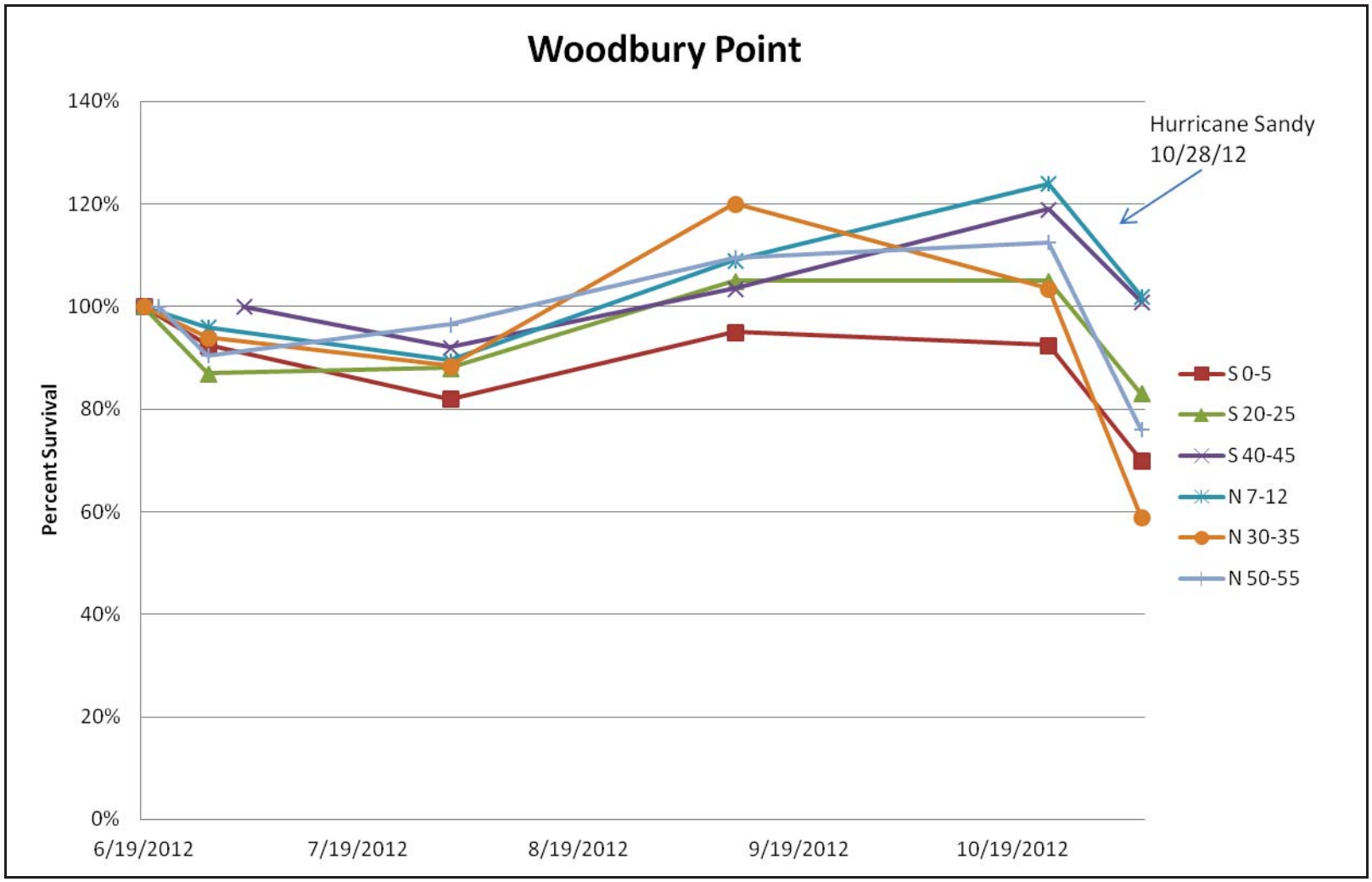


Figure 7. 2012 monitoring results for Woodbury Point. Each line is a planted plot (i.e. S 0-5 is the plot at the south transect 0-meters) (refer to layout in Figure 4.)

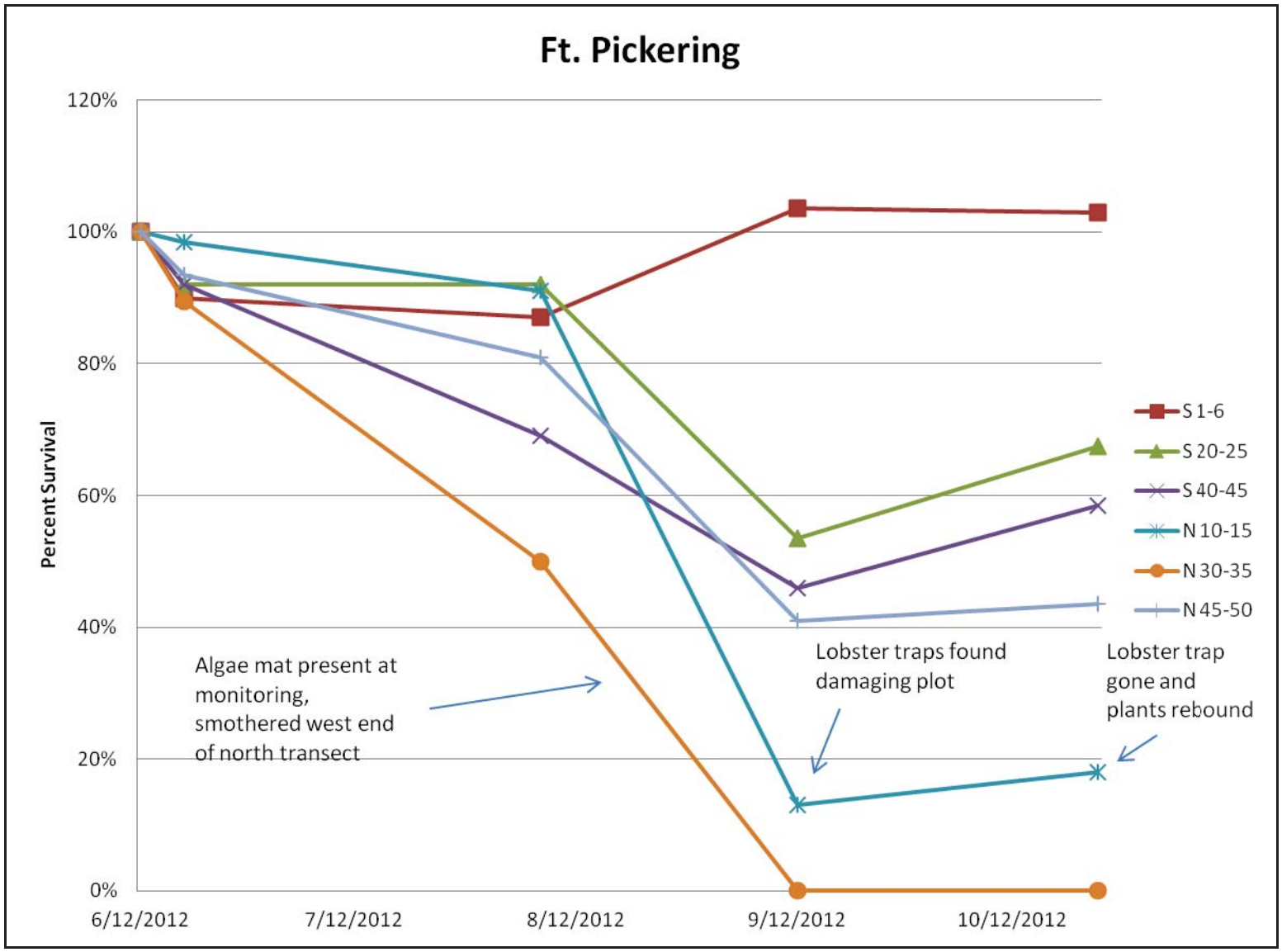


Figure 8. 2012 monitoring results for Ft. Pickering. Each line represents a planted plot.

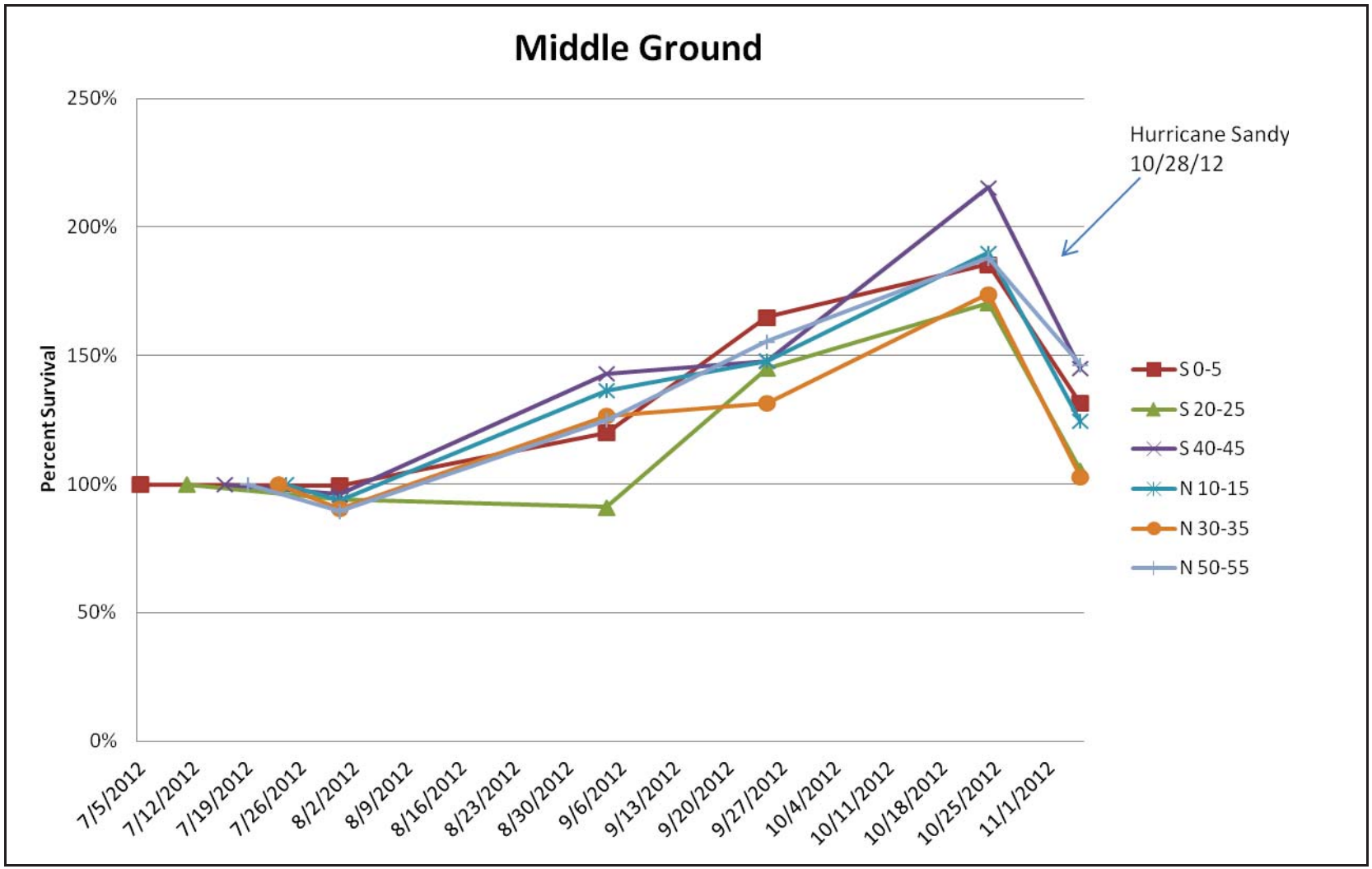


Figure 9. 2012 monitoring results for Middle Ground. Each line represents a planted plot.

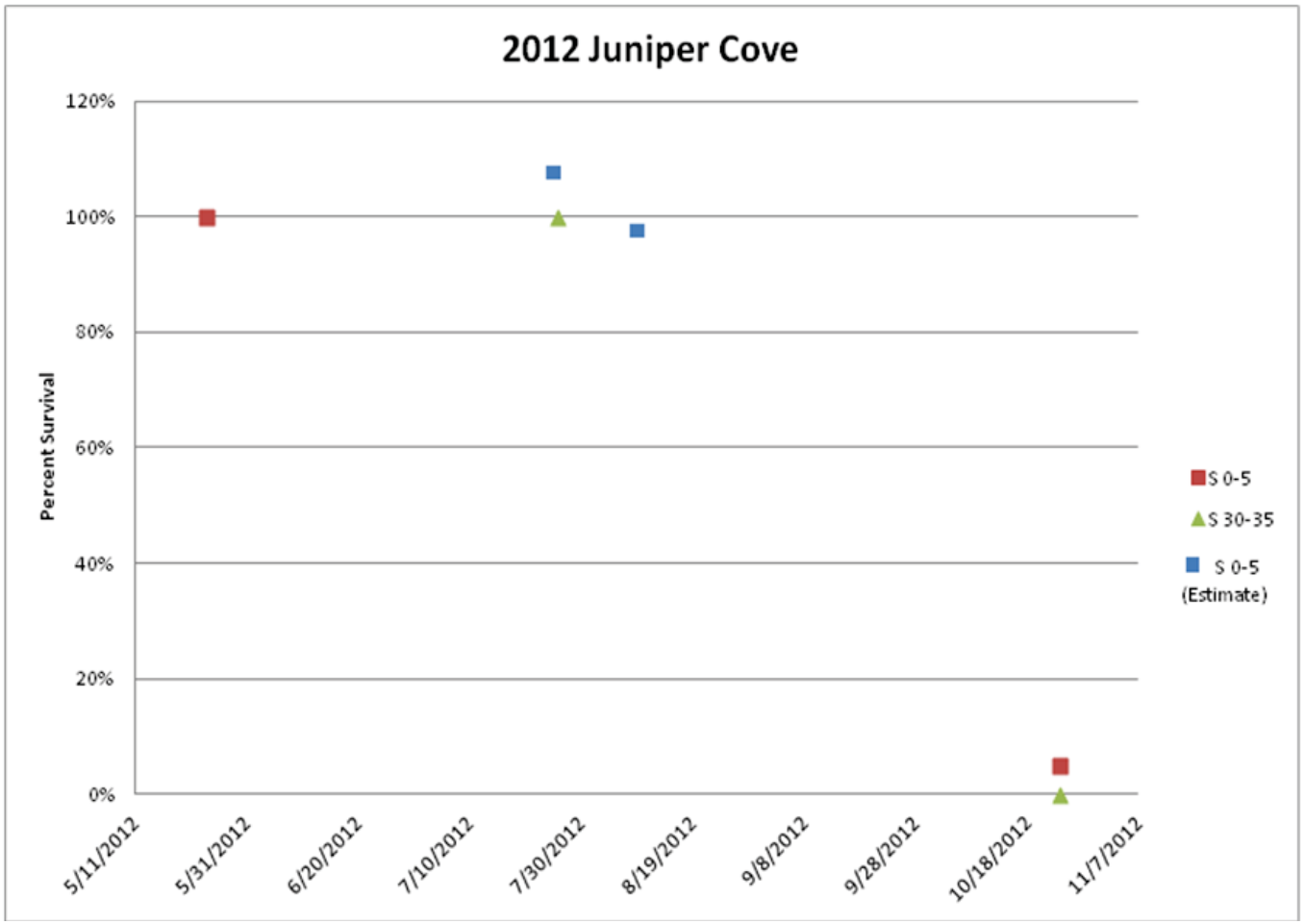


Figure 10. 2012 monitoring results for Juniper Cove. Site was not finished due to poor survival of the planted plots.

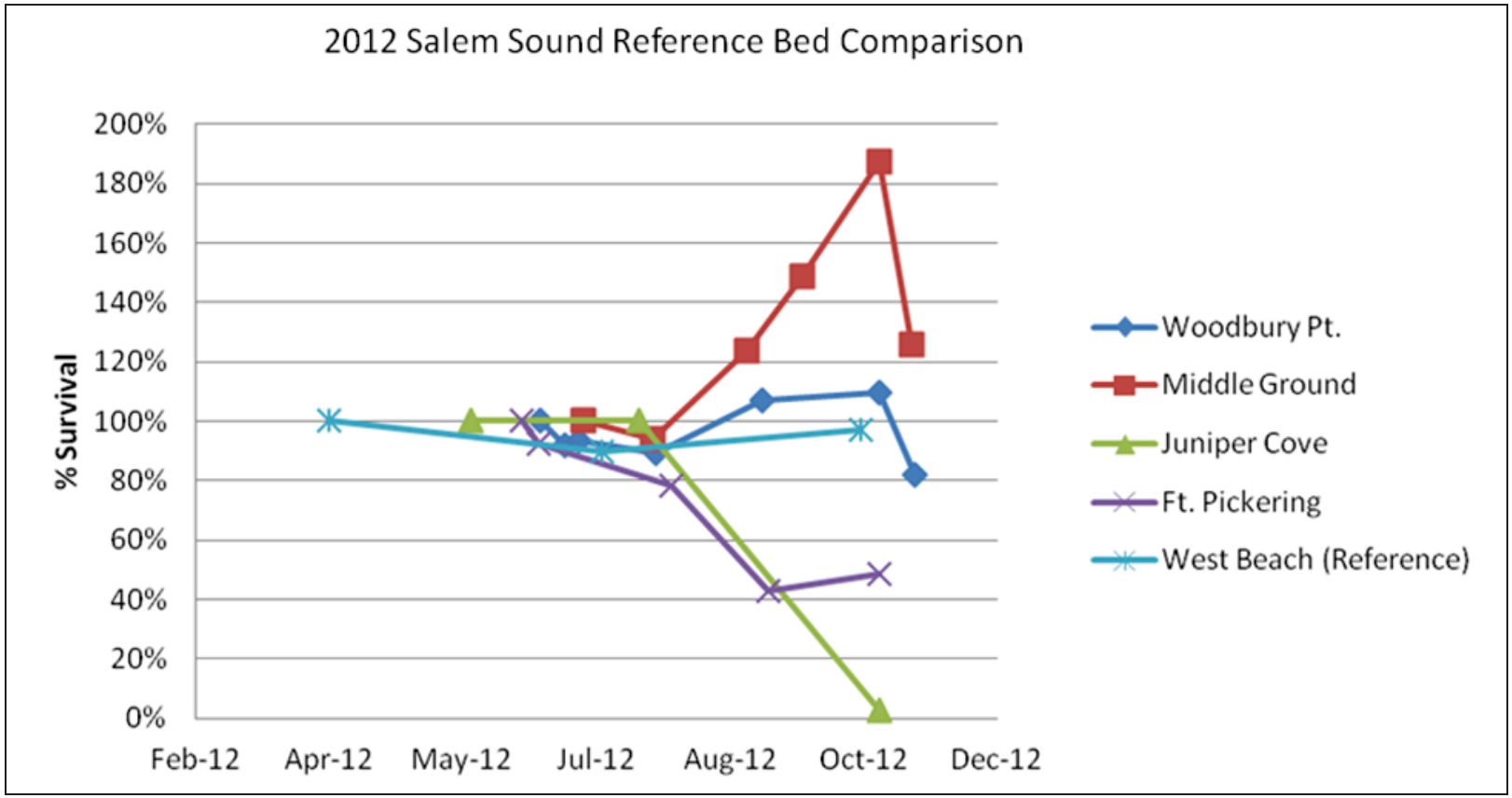


Figure 11. Percentage survival of planted shoots at 2012 Restoration sites vs. percentage change in shoot density at the West Beach reference Bed during the same time period.

Appendix A

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY & ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
ONE WINTER STREET, BOSTON, MA 02108 617-292-5500

DEVAL L. PATRICK
Governor

TIMOTHY P. MURRAY
Lieutenant Governor

IAN A. BOWLES
Secretary

LAURIE BURT
Commissioner

November 24, 2009

Mr. George McLachlan
Manager, Environmental
Algonquin Gas Transmission, LLC
890 Winter Street, Suite 300
Waltham, MA 02451

Re: HubLine Pipeline Project
Amendment to 401 Water Quality Certificate No. W015087 and
Minor Project Modification, Waterways License No. 9451

Dear Mr. McLachlan:

The purpose of this amendment is to authorize, under 314 CMR 4.00 and 310 CMR 9.00, final conditions and additional performance steps that are necessary for Algonquin Gas Transmission, LLC (the Permittee) to complete the requirements of the 401 Water Quality Certificate No. W015087 (WQC) issued by the Massachusetts Department of Environmental Protection (Department) on August 16, 2002 (as amended on March 27, 2003; August 28, 2003; November 17, 2004; and December 23, 2005) and the Waterways License No. 9451 issued by the Department on September 26, 2002 (License 9451).

The project approved under the WQC and License 9451, the HubLine Pipeline Project, involved the installation of approximately 29 miles of 30-inch diameter pipe through the waters of Beverly Harbor, Salem Sound, Massachusetts Bay, Broad Sound, Quincy Bay, and the Fore River. The pipeline was buried approximately 3 to 10 feet below the seafloor primarily using a plow, but horizontal directional drilling, jetting, and conventional dredging techniques were also used. Armoring over the pipeline was used where the pipeline crossed existing utility lines and in other areas where added protection was necessary, such as the Precautionary Area. Post-construction monitoring of eelgrass and benthic habitat were required in the WQC.

As-built conditions of the project are reflected on the plans referenced in Attachment A and on file with the Department, and in a spreadsheet entitled "Hubline Pipeline Project, Imported

Backfill Lengths based on Profile Signature and OSI Post Construction Survey," provided to the Department on March 3, 2009.

Chapter 91 authorization

License 9451 authorized placement of hard cover material at selected locations to protect the pipeline and pre-existing facilities. Placement of hard cover at additional locations was authorized by a permit under § 404 of the Clean Water Act issued by the U.S. Army Corps of Engineers (USACE) on September 22, 2002, at the request of the U.S. Coast Guard and the Massachusetts Office of Coastal Zone Management (CZM), and by the Department in later amendments to the WQC, in order to protect public safety due to the risk of vessel anchor drops on the pipeline. During construction, as documented by the Permittee's weekly status reports and subsequent filings, the Permittee placed hard cover at additional locations in order to protect the pipeline from insufficient burial depth. The locations of the hard cover materials placed over the pipeline are shown on the as-built plans listed in Attachment A. The additional material shown on the as-built plans is hereby authorized as a Minor Project Modification pursuant to 310 CMR 9.22(3).

Post-construction Impact Evaluation

(a) Recovery of benthic habitat

Condition 11 of the WQC required the Permittee to perform up to four years of post-construction monitoring of benthic habitat disturbed by pipeline construction. The purpose of this monitoring was to assess the recovery of benthic habitat conditions within the pipeline route to pre-construction conditions. The sampling and analytical procedures were detailed in the WQC and in the Comprehensive Marine Environmental Monitoring Plan submitted by the Permittee and incorporated by reference into the WQC. Annual meetings between the Permittee and an inter-agency committee comprising the Department, the USACE, the U.S. Environmental Protection Agency (EPA), the National Marine Fisheries Service (NMFS), the Division of Marine Fisheries (DMF), and CZM (the "inter-agency committee") reviewed the results of the surveys. The Third Post-construction Monitoring Report prepared by the Permittee proposed the use of a Weight of Evidence (WOE) approach to evaluate the likelihood that impacts due to construction were still affecting the benthic habitat.

Beginning in the summer of 2008, the inter-agency committee and the Permittee sought to reach an agreement on quantifying the extent to which changes in the benthic habitat proximate to the pipeline should be attributed to the project. Due in part to difficulties in implementing the approved monitoring plan, and due in part to changes in the sampling and analysis methods adopted by the Permittee, the Permittee and the inter-agency committee were unable to reach concurrence on quantifying the degree of benthic recovery. The Permittee's position, using the WOE approach, is that there are no significant net or negative impacts to benthic habitat. The inter-agency committee evaluated the WOE approach and objected to its adoption as the methodology to evaluate post-construction benthic impacts. The inter-agency committee, using

the same data and the agencies' application of the analysis methods set out in the WQC, determined that a significant area of benthic habitat has not recovered.

(b) Hard Cover

There are additional benthic impacts due to placement of hard cover over the pipeline corridor. The Department finds that in excess of 13 acres of hard cover were placed without specific approval in the WQC or any amendments. The Permittee disputes that finding and has provided evidence that the USACE in consultation with cooperating agencies, not including the Department, approved most of this additional material to protect public safety against vessel anchor drops.

Compensatory Mitigation for Post Construction Impacts

Benthic Habitat

Condition 12 of the WQC required appropriate mitigation for habitat found to have not recovered during the monitoring period. The mitigation is to be commensurate with the areas found to have not met the recovery criteria, as determined by the Permittee and the inter-agency committee. Notwithstanding the absence of concurrence by the inter-agency committee and the Permittee on the application of the post-construction impact measurement methodologies, the Department and the inter-agency committee have agreed on the type and amount of compensatory mitigation consistent with their best professional judgment. As it is not practical to replicate the benthic habitat that the inter-agency committee believes has thus far not recovered, the Permittee and the Department, with concurrence of the inter-agency committee, agree that as appropriate mitigation, the Permittee shall provide funding as set forth below for ocean surveys to supplement and aid ongoing data collection for the Ocean Plan under development and later implementation by the Executive Office of Energy and Environmental Affairs pursuant to the Massachusetts Oceans Act of 2008 (Oceans Act surveys). The Oceans Act surveys will collect data on seafloor surface geology that will enable future projects within the surveyed area to conduct suitable alternatives analysis that can help to avoid and minimize future impacts to benthic habitat.

Eelgrass

As required by the WQC, the Permittee conducted pre- and post-construction surveys of eelgrass beds in Beverly Harbor so that any impact of the project to these resources could be determined and mitigated. The inter-agency group and the Permittee reviewed the results of the post-construction surveys in June, 2008 and agreed that a loss of 1.8 acres of eelgrass can be attributed to the HubLine project and requires mitigation.

To implement the mitigation, during the fall and winter of 2008, the Permittee undertook a Site Screening assessment to identify potentially suitable habitat areas to target for restoration planting. The estimated cost of the assessment was $150,000. The Permittee reviewed the results of the Site Screening assessment with the agency committee in early 2009, and the

participants agreed upon the scope and proposed locations of a test planting program to determine suitable locations for replicating eelgrass.

During the spring and early summer, 2009 the Permittee completed and provided a progress report on the approved test planting program. The estimated cost of the program was $250,000. The Permittee also provided a final report on the test planting program dated November 2009 and will provide funding as set forth below for an eelgrass planting effort to be conducted by DMF based on locations selected through the test planting program.

Water Quality Certification Amendment

The Department hereby issues this Amended Water Quality Certification with the following conditions:

Amendment Condition # 1:

The Department hereby authorizes all hard cover material placed by the Permittee in locations identified on the as-built plans listed in Attachment A, on file with the Department, and on the spreadsheet entitled "Hubline Pipeline Project, Imported Backfill Lengths based on Profile Signature and OSI Post Construction Survey," provided to the Department on March 3, 2009.

Amendment Condition # 2

The Department accepts the Hubline Pipeline Project Eelgrass Restoration Test Planting Evaluation dated November 2009 as the final report ,and has evaluated the results in accordance with the test plot scope of work approved by the interagency group
Amendment Condition # 3:

Within 20 days of the date of this amendment the Permittee shall provide $700,000 payable to DMF to fund the planting of eelgrass in accordance with the findings of the test program. Within 20 days of the date of this amendment the Permittee shall place an additional $100,000 in an escrow account established by and managed by DMF to be used in the event that replanted eelgrass is unsuccessful and requires additional planting. In the event that the initial planting of eelgrass costs less than $700,000, the remainder of the $700,000 committed shall be placed into the escrow account. The cost to monitor will be paid from the escrowed funds. If during the monitoring period, it is determined that some or all of eelgrass plots need to be replanted or replaced, any costs associated with the harvesting and replanting or replacement of eelgrass will be paid from the escrowed funds. If at the conclusion of the monitoring period, DMF determines that no further replacement planting is necessary, the balance of any funds in the escrow account will be remitted to the Permittee. The inter-agency group has considered the length of time necessary to complete, monitor and replant unsuccessful plot(s) if necessary. It is uncertain at present whether planting would commence in the Spring of 2010, or 2011. The inter-agency group has also discussed the possibility of spreading the initial planting efforts over two years. Following the planting of each plot a 3-year monitoring period will be necessary and then potentially portions of two calendar years will be needed to undertake replanting unsuccessful

plots if necessary. Based on these estimated timelines the Permittee's eligibility for a refund of any unspent money will be determined in December of 2017.The completion of Amendment Condition # 2 and payment of all funds in accordance with this condition fully satisfies the Permittee's obligations under the WQC and License No. 9451 for project impacts to eelgrass.

Amendment Condition # 4:

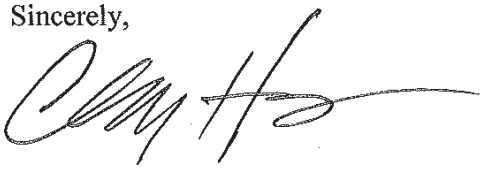
Within 30 days of the date of this amendment the Permittee shall pay $1 million to the Ocean Resources and Waterways Trust Fund to compensate for impacts to benthic habitat resulting from pipeline placement and the addition of hard cover over the pipeline. Said funds shall be disbursed by the Executive Office of Energy and Environmental Affairs to conduct benthic surveys. The payment of all funds in accordance with this condition fully satisfies the Permittee's obligations under the WQC and License 9451 for project impacts to benthic habitat and placement of additional fill material.

Upon full completion of Amendment Conditions # 2 to # 4, the Permittee shall have no further obligations under the WQC or License 9451 to monitor and assess the impacts of the construction of the HubLine Pipeline Project on the ocean and ocean bottom. The Department reserves its authority to require monitoring and assessment of future activities such as operation and maintenance or modifications to the HubLine.

In accordance with the provisions of Section 401 of the Federal Clean Water Act, 33 U.S.C. § 1251 et seq., M.G.L. c.21, §§ 26-53, and 314 CMR 9.00, the Department has determined there is reasonable assurance the project or activity will be conducted in a manner which will not violate applicable water quality standards (314 CMR 4.00) and other applicable requirements of state law.

Please continue to keep the Department informed regarding the progress of the work. If you have any questions on this decision, please contact Alex Strysky at (617) 292-5616.

Sincerely,



Glenn Haas, Acting Assistant Commissioner
Bureau of Resource Protection

Cc: Ted Lento, Regulatory/Enforcement Division, U.S. Army Corps of Engineers
696 Virginia Road, Concord, MA 01742-2751
Bob Boeri, CZM, 251 Causeway Street, Suite 900, Boston, MA 02114
Vin Malkoski, Division of Marine Fisheries, 838 South Rodney French Blvd,
New Bedford, MA 02559

ATTACHMENT A

As-built plans entitled "Hubline Pipeline Project" prepared by Duke Energy Gas Transmission/Algonquin Gas Transmission Company:

TABLE 1

Plan Title	Drawing No.	Date
Area Map	M7-L-1000-AB Rev. 6	9/25/01, revised 4/11/05
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1001-AB Rev.3	9/20/01, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1002-AB Rev.4	9/21/01, revised 6/28/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1003-AB Rev.2	9/20/01, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1004-AB Rev.3	9/20/01, revised 4/11/05
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1005-AB Rev.2	9/20/01, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1006-AB Rev.2	9/20/01, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1007-AB Rev.4	9/20/01, revised9/24/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1008-AB Rev.4	9/20/01, revised9/24/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1009-AB Rev.1	2/6/04, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1010-AB Rev.1	2/6/04, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1011-AB Rev.1	2/6/04, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1012-AB Rev.1	2/6/04, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1013-AB Rev.1	2/6/04, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1014-AB Rev.1	2/6/04, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1015-AB Rev.1	2/6/04, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1016-AB Rev.2	2/6/04, revised 9/24/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1017-AB Rev.1	2/6/04, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1018-AB Rev.2	2/6/04, revised 4/11/05
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1019-AB Rev.1	2/6/04, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1020-AB Rev.1	2/6/04, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1021-AB Rev.1	2/6/04, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1022-AB Rev.3	2/6/04, revised 4/11/05
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1023-AB Rev.2	2/6/04, revised 4/11/05
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1024-AB Rev.1	2/6/04, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1025-AB Rev.3	2/6/04, revised 4/11/05
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1026-AB Rev.3	2/6/04, revised 4/11/05
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1027-AB Rev.1	2/6/04, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1028-AB Rev.1	2/6/04, revised 6/7/04
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1029-AB Rev.3	2/6/04, revised 4/11/05
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1030-AB Rev.3	2/6/04, revised 4/11/05
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1031-AB Rev.3	2/6/04, revised 4/11/05
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1032-AB Rev.1	2/6/04, revised 6/7/04
360 Network Cable Crossing Detail (360 Networks)	M7-D-1001-AB Rev.3	11/13/01, revised 6/7/04
60" Easterly Sewer Outfall 60" Sewer Line Crossing Details	M7-D-1005-AB Rev.3	11/13/01, revised 6/7/04
Area Map	M7-L-1000-AB Rev. 7	9/25/01, revised 3/15/06
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1022-AB Rev.4	2/6/04, revised 3/14/06
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1024-AB Rev.2	2/6/04, revised 3/13/06
30" OD Natural Gas Pipeline Alignment and Profile	M7-A-1025-AB Rev.4	2/6/04, revised 3/13/06

Appendix B

Deval L. Patrick
Governor
Timothy P. Murray
Lieutenant Governor

Commonwealth of Massachusetts
Department of Fish and Game
251 Causeway Street, Suite 400
Boston, Massachusetts 02114
(617) 626-1500
fax (617) 626-1505

Ian A. Bowles
Secretary
Mary B. Griffin
Commissioner

December 23, 2009

Patrick J. Hester
Assistant General Counsel
Spectra Energy Corp.
890 Winter Street, Suite 300
Waltham, MA 02451

Re: HubLine - Amended MassDEP Water Quality Certificate
Deposit of Payments into DMF's Marine Fisheries Research and Conservation Trust

Dear Mr. Hester:

I am responding on behalf of the Division of Marine Fisheries ("DMF") in the Massachusetts Department of Fish and Game. This letter is to confirm that DMF has received two payments from Algonquin Gas Transmission, LLC ("AGT") pursuant to the Amended Water Quality Certificate (the "Amended WQC," copy attached) issued on November 24, 2009 by the Massachusetts Department of Environmental Protection ("DEP") to AGT. Specifically, the payments made by AGT to DMF pursuant to the Amended WQC are as follows:

1. A payment of $700,000 to support a program of eelgrass restoration to be implemented by DMF; and

2. A payment of $100,000 to be held within the Trust for DMF to use on the eelgrass restoration program, if necessary.

DMF has accepted both payments, subject to the terms of the Amended WQC, and deposited them into DMF's *Marine Fisheries Research and Conservation Trust*, an expendable trust established by the Commonwealth pursuant to M.G.L. c. 6A, s.6 and 801 CMR 50.00 (the "Trust"). DMF agrees to provide an annual report to AGT and DEP on the progress of DMF's implementation of the above eelgrass restoration program and its related expenditure of the funds. In addition, in the event that DMF completes the

eelgrass restoration program without using the entire $700,000 and $100,000, DMF will return the unused amounts to AGT in accordance with the terms of the Amended WQC.

By your signature below, AGT accepts this letter in lieu of establishing an escrow arrangement as described in the Amended WQC. Thank you for your assistance and cooperation in this matter.

Sincerely,

Richard Lehan

Richard Lehan
General Counsel
Department of Fish and Game
Commonwealth of Massachusetts

Patrick J. Hester, duly authorized
Spectra Energy Corp.

Attachment (Amended WQC)

cc: Kevin Creighton, CFO, DMF
Kathryn Ford, DMF
Lealdon Langley, DEP
Deerin Babb-Brott, EEA

Appendix C

2011 Status Report posted on www.SeagrassSoundings.blogspot.com on 10/19/2011

I'd like to provide a brief update on the status of the HUB3 restoration project and our team's plan for the rest of this field season. This will serve as our 2011 annual report.

Planting

Field work began this season on May 23. Wes, Mark and I together with dive help from Vin and Holly, harvested plants from the Logan Airport runway safety area (RSA) improvement project footprint and planted test plots at Long Island and Lovell's Island. We also investigated Thompson's Island but were not able to find any suitable sites due to the silty organic sediment. We continued to harvest through the month of June and transported plants up to Beverly, planting them at the impact site (a.k.a Woodbury Point). By the end of June we shifted to harvesting plants at a donor bed in Beverly off of Pride's Beach (SW of the SeagrassNet site) and continued planting our ½ acre site. At this point we went to a two person dive scenario every day with two of the three of us diving (Wes, Tay or Mark). We brought on Andrew Weinstock in July to replace Paul who was terminated due to poor performance in the winter of 2010. Andrew trained with Holly and received his DMF dive qualifications in mid-August. Unfortunately, Mark suffered an injury in August that has prevented him from diving since then.

Monitoring

Our one month monitoring on July 20, 2011 of two plots at the Beverly site showed 97% of our planted squares were present, but shoot density had declined about 50% (i.e. average of 12 shoots from 24 planted). The fact that we could find almost all of the planted squares was encouraging, but the condition of the squares was not – low density, wasting disease on the leaves and encrusting membranipora on the leaves. From the beginning, we considered the site somewhat risky for restoration since it's a deep edge. However, its high rating in the site selection model, the success of Battelle test plots at the site, and the presence of natural grass growing between our plots influenced our decision to plant the site. Also, the site is the HUBline pipeline impact site where grass was growing in 2002 before pipeline construction. This weighed heavily in the decision to replant there. The initial low density of the plots could be explained by several factors. Human error in planting may have caused some loss of plants. We did not re-count a day or so after planting to be sure of how many shoots were actually planted, so 24 may be an overestimate of the time zero density. Additionally, the Boston plants were taken from a shallow site off of Logan airport and transplanted to a deeper site in Beverly. Plants may be better able to adapt to new sites that have similar light, temperature and sediment conditions. The two sites had different depths and different sediment conditions (sand in Beverly and sand and clay in Logan). The difference in depth could lead to the conclusion that the donor plants may have been light adapted, having grown up at the shallower site. However, light data is higher at the Beverly deep site (mean 3.14 % light and 332.8 lumens/ft^2 from June 2011) compared to the Boston site (1.569% light and 198.3012 lumens/ft^2 from July 2010).

At the end of August the plants were surviving with evidence of some new growth but still at a low shoot density. It is possible that they could have rebounded. However on August 28, Hurricane Irene hit Beverly. After the hurricane, Wes and Andrew monitored all of our Beverly plots. They reported large sand waves across the site and a loss of approximately 75% of the planted squares. The site has some rows of grass without sand waves, but most of the squares are now bare sand. There is no clear trend indicating differential survival of plants transplanted from either Beverly or Boston or to the shallow or deep portions of the site. Plot B1-4 was planted with all Boston plants. Half of the plot now has low density grass and the other half is no longer vegetated. The plants that are there are rooted and show evidence of new growth. B3-4 was planted with 4 rows of Boston plants and 8 rows of Beverly plants. The side with the Boston plants was not hit by the sand waves and still persists, while the Beverly plants are mostly gone. The deeper A plots are a mix of Boston and Beverly plants and are uniformly patchy and 25% vegetated.

Test - plots at Lovell's Island and Long Island have fared well and were unaffected by the hurricane.

Fall Test-plots

This fall we shifted our focus from the Beverly restoration site to plant several test-plots at sites throughout Salem Sound and Boston Harbor. In September test –plots were planted at the SE side of Long Island, the SE side of Peddocks Island in Boston Harbor and Middle Ground and Juniper Cove in Salem Sound. We will continue to plant test-plots and monitor their progress through the month of October.

This week, provided the weather improves, we will be test-planting a site at the beach near Fort Pickering and one at the Salem Willows. Chris Pickerell of Cornell Cooperative Extension on Long Island will be visiting and working with us in the field to test his new method of planting with shoots woven into burlap circles, dubbed the tortilla method. This method may be preferable to the horizontal rhizome (HR) method in some conditions. We are planning to plant test-plots of two treatments (HR method and tortilla method) at Fort Pickering and Salem Willows this week. Our field work will wrap up in the last week of October or first week of November for the winter season.